BIOMECHANICAL ANALSYSIS FOR PREDICTION OF TENNIS TOP SPIN SERVICE BASED ON MUSCLE ACTIVATION AND KINAMATIC VARIABLES

SHORT SYNOPSIS

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(Deemed to be University**)**

by

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Certificate

I hereby declare that the short synopsis titled "**biomechanical analsysis for prediction of tennis top spin service based on muscle activation and kinamatic variables**" is being submitted in partial fulfilment of the requirement for the degree of Doctor of Philosophy in Physical Education under the Department of Exercise Physiology, Lakshmibai National Institute of Physical Education (LNIPE), Gwalior during the academic year 2021–2022.

It is a Bonafide record of original research work carried out under the supervision of Dr. Madan Singh Rathore, and has not been submitted either in full or in part to any other university or institute for the award of any degree or diploma. It is further certified that the short synopsis is plagiarism-free, and the plagiarism report has been submitted along with this document.

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ABSTRACT

This study investigates the Biomechanical factors influencing the prediction of a top spin tennis service, focusing on muscle activation pattern and kinematic variables. For this study 10 male university players will be selected from the LNIPE Gwalior. Muscle activation data will be collected through the EMG with key muscle groups including Triceps brachii, Flexor carpi radialis, medialis Deltoid, Vastus lateralis, Vastus medialis, gastrocnemius. The biomechanical analysis of Tennis Serve videography will be employed, GO PRO HERO 5 with the frequency of 240 frames per second was placed on the sagittal plane. For the tennis serve accuracy and speed tennis Hewitt test will be used for data collection. In order to find out the prediction of tennis serve performance on the basis of muscle activation and kinematic variables stepwise multiple regression statistics analysis will be used. This study is expected to be significant prediction of tennis serve Accuracy performance, serve speed performance on the basis of selected kinematic and selected muscles variables.

KEYWORDS: Electromyography (EMG), Biomechanical variables, Tennis service (Accuracy and Speed).

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CHAPTER I

INTRODUCTION

Biomechanics is an applied form of mechanics and consequently the method used to investigate, it must be derived from those of mechanics. However, biomechanics have not developed in the wake of mechanics but as bordering science in other scientific discipline such as anatomy, physiology and technique of sports (Gerhard Hochmuth, 1984).

Movement or biomechanical analysis is used to compare the performance with the standard guidelines and also to analyze the performance of skill, checking the faults in performance, providing guidance to performers to help them to correct those faults. Although these steps are the parts of biomechanical process. (McGinnis, 2005)

Basic knowledge about body's movement, in what degree and proportion maximum output can be achieved and what are the main group of joints and muscles involved during any sports technique. An understanding of nature of a skill is provided by moment analyst, which involves dependent factor in varied situations, which help to build a larger scheme of economic movement. (Wickstrom, 1977)

Knowledge of basic biomechanical concepts is also essential for the competent physical education teacher, physical therapist, physician, coach, personal trainer, or exercise instructor(Susan J. Hall,2003).

Analysis involves examining something after breaking down in small parts. In current year's biomechanics research have marked increasing at theoretical practical and basic levels. Because this work becomes more difficult and complicated, it is important for researchers to enhance their experimental procedures, instrumentation, data recording, methods of analysis and way of dominating their findings. The ultimate achievement of research in biomechanics in sports will rely very much on the imagination and capability of researchers in their continued hard work for more successful way of investigating human movement.(Miller & Nelson, 1973)

Videography is the process of capturing images on a videotape or directly to a computer, also used to include the later analysis of these images(Roger Berlet,1954).

Tennis is a game played by people of all ages and of all skill levels. Courts are filling with more and more players as individuals come to realize the value of Tennis as a leisure-time activity, the relationship of physical exercise to health, and the satisfaction of participation. In addition, Tennis is becoming a year-round activity as indoor courts are developed to supplement the traditional outdoor arrangement (Wayne Pearce, Janice Pearce,1971).

Success in Tennis is greatly affected by the technique a player uses and biomechanics plays an

integral role in stroke production. All strokes have a fundamental mechanical structure, and sports injuries primarily have a mechanical cause. Player's development based on scientific evidence allows an individualized approach to be structured, with due consideration to the key mechanical features of each skill, while also fostering flair and permitting the physical characteristics of a player to be considered. An understanding of biomechanics from a perspective is also important if player development is to occur with minimal risk of injury. By obtaining an understanding of the biomechanics involved in each Tennis stroke, coaches are able to direct athletes to use their muscles in the most efficient and injury-free ways(B.Elliot,2006).

Tennis is a unique game and most tennis players have different looking tennis strokes. No one player hits their tennis forehand or backhand the exact same way nor should they aim to; however, when looking at the tennis technique of top professional players closer through slow motion video, some interesting discoveries about tennis technique can be observed.

There are similarities in fundamental components in tennis technique which are shared by professional players - and these elements are usually not present in players at the recreational, club tennis and sometimes junior levels.

One of the elements that all high level tennis players, college tennis players and world class tennis professionals share is efficient and biomechanical sound tennis strokes. In each of these groups, the higher level players share commonalities and distinct fundamentals of tennis technique. Although each player should have their own hitting and playing style, they all have basic technical elements in place that separate them from lower level players.

The most successful serve is that where player hit the ball with slightly bent elbow, but the arm completely extended while doing contact with the ball above the server's body. To start sequence of the serve, when the ball is tossed in the air, at the time of contact the players body uncoil itself with the complete extension from the coiled body. To attain maximum power throughout this mechanism of uncoiling the body, the player's torso twist, racket swing, and the force upwards of the legs in the direction of the ball all come together to produce better speed in the racket. As a common theory of physics, the higher the speed of racket in leading contact with the ball, the faster the tennis ball will move, as the higher racket velocity assist into larger force to the ball and resulting velocity gained by the ball on contact. (Thomson, 2007)

One of the important feature of the of a tennis serve mechanics is the exact point at which the ball is strike. If the toss of the ball is too low, there will be problem in the full extension of the arm at contact and this leads to decrease in the quantity of force applied into the ball on contact. An additional thought of doing

low toss in the serve is that the lower the height of impact between racket and ball, the more possibility that the ball will be go into the net. When the toss of the ball is too high, research have revealed that the player will also strike the ball at a low height than optimal; while tracking the ball at the point over them, players permit the ball to drop too far prior to hitting it with the racket. To protect mechanics of service, the height of tossing the ball should be preferred height and strike on its rise, at the time the ball picked its peak height. (Thomson, 2007)

The final position of the player at the time of moment contact is a main mechanical matter. When the player hit the ball, for a right handed player the right foot of 11 him will control during the stance, helping the player to get within the court. The player must perform the serve in crouched (bent knee) position, in order to quick respond to the upcoming shot of the other player (opponent). (Thomson, 2007)

Most players are assumed with the goal of hitting their serves harder. But sheer pace is rarely the answer to a better serve. Holding serve more regularly-and consequently winning more matches-requires the maturity to switch the focus from power to variation and consistency. The common serving strategy found at every club is to kill the first serve and then, depending on the level, dink or kick the second serve. This routine has no variation, and the code is easy to crack. (Giampaolo & Levey, 2013)

First, if a player enjoys achieving a numerical goal, he should switch the focus from increasing the number on the radar gun to bettering his first-serve percentage. Second, applying variations of first and second serves is crucial for keeping an opponent uncomfortable. An intelligent server mixes the speed and spin of the serve so that the returner is reactive and constantly guessing. However, once a weakness is found, a savvy server mines that vein until the gold runs dry.(George, Bruce, & Lorge, 2019)

Electromyography is the technique of recording the electrical activity of motor unit firing. Not muscle force per se, but the electrical signal sent by the motor nerves to muscle fibres to create force. The electromyogram is the trace of the electrical signal detected by the electrode. Uses electrodes applied on the skin (surface) or implanted into the muscle (indwelling) as “antennas” to pick up voltage signals. Similar to ECG (EKG) – ECG is in fact electromyography of the heart muscle.The EMG signal (as perceived from surface electrodes) is composed of many individual motor unit action potentials (MUAPs). Each MUAP has its own unique firing profile. Muscular efforts usually require the activation of more than 1 motor unit. According to Henneman’s size principle, to increase strength; you recruit increasingly large, rapidly firing motor units. The result is a curve summation that can be difficult to analyze and interpret.

This study I'll going to analyse the TOPSPIN SERVE in tennis in which going to measure the ideal range of angular kinematic and linear kinematic variables. This study will help the physical education teacher

and tennis coach to improving topspin service performance in tennis.

STATEMENT OF THE PROBLEM

The statement of the problem to analyse the tennis serve biomechanically & to predict its effectiveness based on muscle activation and kinematic variables.

OBJECTIVES OF THE STUDY

The objective of the present study will be to determine the muscle activation and Kinematic variables based on biomechanical analysis for the prediction of tennis serve.

DELIMITATIONS

1. The study will be delimited to 10 male university level Tennis players only.
2. The study will delimit to right-handed LNIPE tennis players.
3. The study will be delimited to Top spin service in tennis.
4. The study will be delimited to (stance position, preparatory phase,ball contact phase and follow through of topspin service stroke in tennis.
5. The study will be delimited to the following selected kinematic variables.

Linear kinematic variables

- Height of the center of gravity at Stance Position.
- Height of the center of gravity at preparatory phase
- Height of the center gravity at the time of moment contact
- Height of the center of gravity at follow through

Angular kinematic variables

- Angle at right ankle joint.
- Angle at right knee joint.
- Angle at right hip joint.
- Angle at right shoulder Joint.
- Angle at right elbow joint.
- Angle at right wrist joint.

6.The study will be delimited to following muscles

- Triceps brachii
- Flexor carpi radialis

- Medial Deltoid
- Vastus medialis
- Vastus lateralis
- Gastrocnemius

Hypotheses

Based on expert opinion, reviews and scholar's own understanding of the problem: -

1. It may hypothesized that there will be significant prediction of tennis serve accuracy performance on the basis of selected kinematic and selected muscles variables.

2. It may hypothesized that there will be significant prediction of tennis serve speed performance on the basis of selected kinematic and selected muscles variables.

DEFINITION AND EXPALNATION OF TERMS

Biomechanics

"Biomechanics is the science concerned with the internal and external forces acting on a human body and effect produced by these forces". (Physiopedia, 2019)

Angular Kinematics

"Angular kinematic is the process of measuring the kinematic quantities used to describe motion. It also deals with the rotation or the angular motion. Angular kinematic deals with the rotation or the angular motion however; it doesn't study the cause of angular motion."(Hay, 1993) Center of Gravity "It is an imaginary point around which the gravitational force seems to work. It is point at which the sum of all masses of the body seems to be concentrated. As it is an imaginary point, the COG should not lie inside the physical limits of a person or object." (contributors, 2017)

Tennis

"Tennis is a racket sport in which either two or 4 players hit a ball with racket over or around net extended crossways in court .The normal form is played on a grass, clay or artificial surface with a covered hollow rubber ball." (George, Bruce, & Lorge, 2019)

Tennis Serve

"The game of tennis is start with a serve. A player has to strike the ball with the racket in such a way that the ball has to land into the opponent's right service box without touching or stopping by the net. Usually, players start a serve by tossing the ball into the air and striking it. While striking a serve if the ball touches the net and land to the correct service box it is called "Let" this is neither called valid serve nor fault serve. The players will get another serve instead of this. The players can do any type of serve overhead or underhand."(Roetert & Groppel, 2001).

SIGNIFICANCE OF THE STUDY

The modern age of sports is the excellences in every perfection and purification of skill has got its immense importance and research in field has added allow in excelling the performances of the present study may be contribute to the following:–

1. This study provides knowledge about tennis service (topspin serve) technique in relation to the angle of approach of the racket and placement of the ball. The study may also reveal the mechanical aspect of the whole patterns of movement.

2. Tennis experts, coaches and players take the advantage of the opinion provided to them about their execution of service.

3. The finding of present study determines contributing feature to the execution of serve in tennis.

4. The study helps the players to improve the performance of serve in tennis.

5. The finding of the study also helps the coaches to identify errors while teaching serves to fresher.

6. The outcomes of this study are helpful in preparing technique model of tennis serve.

7. The results of this study reflect the most significant muscle activation that affecting the technique of serve and overhead smash.

REVIEW OF RELATED LITERATURE

(John et al., 2009), conducted a study on Lower trunk kinematics and muscle activity during different types of tennis serves.To better understand the underlying mechanisms involved in trunk motion during a tennis serve, this study aimed to examine the (1) relative motion of the middle and lower trunk and (2) lower trunk muscle activity during three different types of tennis serves - flat, topspin, and slice.Tennis serves performed by 11 advanced (AV) and 8 advanced intermediate (AI) male tennis players were videorecorded with markers placed on the back of the subject used to estimate the anatomical joint (AJ) angles between the middle and lower trunk for four *trunk motions* (extension, left lateral flexion, and left and right twisting). Surface electromyographic (EMG) techniques were used to monitor the left and right rectus abdominis (LRA and RRA), external oblique (LEO and REO), internal oblique (LIO and RIO), and erector spinae (LES and RES). The maximal AJ angles for different trunk motions during a serve and the average EMG levels for different muscles during different phases (ascending and descending windup, acceleration, and follow-through) of a tennis serve were evaluated.The repeated measures Skill × Serve Type × Trunk Motion ANOVA for maximal AJ angle indicated no significant main effects for serve type or skill level. However, the AV group had significantly smaller extension ($p = 0.018$) and greater left lateral flexion ($p = 0.038$) angles than the AI group. The repeated measures Skill × Serve Type × Phase MANOVA revealed significant phase main effects in all muscles ($p < 0.001$) and the average EMG of the AV group for LRA was significantly higher than that of the AI group ($p = 0.008$). All muscles showed their highest EMG values during the acceleration phase. LRA and LEO muscles also exhibited high activations during the descending windup phase, and RES muscle was very active during the follow-through phase.Subjects in the AI group may be more susceptible to back injury than the AV group because of the significantly greater trunk hyperextension, and relatively large lumbar spinal loads are expected during the acceleration phase because of the hyperextension posture and profound front-back and bilateral co-activations in lower trunk muscles.

(hoon-sik lee, 2009),This research's purpose is to gain information of EMG of player's Prime Mover during the flat and top spin serve, and to identify the regulating mechanism for each server's characteristics. The test subjects were 6 high school tennis players(3male, 3 female) and the EMG measurement machine was Muscle tester ME 3000P(Finland, ,1996) produced by Finland Mega Electronics Ltd.. We attached electrodes to 4parts in left lower leg muscles (Vastus medialis, Vastus lateralis, Tibialis anterior, Gastrocnemius) and in the right upper arm muscles (Deltoid, Triceps brachii, Flexor carpi radialis, Flexor carpi radialis) and at the frequency of 1000Hz, gained "Sampling raw data" from the start to the end of tennis serve, obtaining average integrated EMG, which was the dependable variable of the experiment. Data was analyzed by the SAS 9.1 ver and indicated following conclusions. 1. At the upper arm muscle, male players have high average EMG than female players at the Triceps brachii(TB), whreas the female player has higher averge EMG in Deltoid(DE),flexor carpi radialis(FCOR) then male players.

2. At the lower leg muscle, the male players have high average EMG at Vastus medialis(VM), Vastus lateralis(VL), Gastrocnemius(GA) than female players but there was not significant diffence at Tibialis Anterior(TA).

3. During the top spin serve, average EMG signal was statistically high at the Triceps brachii(TB),Flexor carpi radialis(FCAR) then when the flat serve.

4.During the tennis serve, in the upper, Deltoid function as the Prime Mover which has the most muscle mobility and in the lower leg muscle, Vastus medialis functions as the Prime mover which has the most muscle mobility.

(Wong et al.,2010) studied on"Kinematic Study of Serve Velocity of Hong Kong Elite Tennis Players. Effective training for improving serve velocity is important for elite tennis players. Twelve Hong Kong Tennis Team male players were recruited. Body kinematics of the players during tennis serves were monitored by a motion analysis system (Vicon MX, Oxford Metric, Oxford, UK) and correlated with the ball velocity. Compared to the Olympic 2000 tennis players, the front knee peak extension velocity, pelvic peak axial rotation velocity, trunk peak right rotation velocity, shoulder peak internal rotation velocity, elbow peak extension velocity and wrist peak flexion velocity of the Olympic players were 5, 2.1, 4.1, 2.9, 2.8 and 2.9 times, respectively, faster than those of the Hong Kong Elite Players. The mean serve velocity of Olympic players (182.9+/-14.0 km/h) was significantly faster than that of the Hong Kong Elite players (145.4+/-19.9 km/h; range: 119-180). The velocity of tennis serve of Hong Kong Elite players was within the range of the lower-level tournament western players. The slower ball velocity of Hong Kong Elite players might be due to the differences in kinematic profile during serve. It was also found that the right shoulder peak internal rotation velocity, right rear knee range of motion, right rear hip peak extension velocity, right shoulder rotation range of motion and body weight were significantly correlated with the ball velocity. Stepwise linear regression analysis showed that the right shoulder peak internal rotation velocity and body weight were significant predictors for ball velocity which contributed 3.8%, 85% respectively to the total 25 variability.

(Chang B.F., (2010)),examined in "both amateur and professional tennis competition, factors influencing precision of recognize placement of tennis serve can be critical and impactful. To study this influential factor scientifically, to recognize pivotal tennis serving motion captured by high speed camera system 76 college student with primary experience of playing tennis were recruited. Recording both their participant were than monitored by a computerized cognitive neural response testing system. To analysis test result factorial ANOVA and t- test, with the statistical significances set at $\alpha = 0.5$. For example, participant needed longer average reaction time ($p < 0.5$), in responding to a right hand server serving wide form advantage line. The factors' interaction were shown impactful result of this study can contribute in both practical game situation as well as training campaigns.

(Dossena et at.,2016)administered a study on The Role of Lower Limbs in the course of Tennis Serves was conducted.8 elite players of tennis (20±3 years of age; height 181±3 cm; playing experience 13±3 years; height with racquet: 283±5 cm) were measured with counter movement jump (CMJ) and CMJ with free arm swing (CMJF). Addition, serve speed and jump height through 1 st and 2nd serve were calculated. None of the two serves 1 st and 2nd jump height showed the notable differences. Major difference found between the best jump height during the first (44.46±6.22 vs 12.42±3.28, P=0.0006; ES: >2.0) and the second (44.46±5.82 vs 13.04±2.46, P=0.0002; ES: >2.0) serves and the best CMJF performance were detected. Significant difference in between height of jump through the 1st and the 2nd serve and the best CMJ was noted. Somewhat significant Spearman positive relationship between height of the jump and speed of the 1 st serve was calculated. To serve faster had to reach higher impact point during tennis serve. At the same time, tennis service is a compound synchronized movement of whole kinetic chain; coaches supposed to be concentrate extra on coordinative ability of their tennis player.

(Eriksrud et at., 2018) examined national and international level male tennis players serve performance predict with studied Upper and lower body power tests. Successful result of the tennis serve is firstly dependent on speed (1), which is an outcome of efficacious full kinetic chain function (2-5). Certain mechanical determinants, kinematic and kinetic variables that accord to serve speed had identified (2, 4, 6-9). However, in tennis current tests of physical fitness do not target all mechanical determinants (10-20). Carrying out of tests that aim known mechanical determinants in full kinetic chain motion have been called for (3, 21). The motive of this study was to determine the relationship between force, full kinetic chain tests of dynamic postural control and power that target known mechanical determinants of tennis serve performance. 33

(P.bisht,2019) The purpose of the present study was to determine the Kinematic variables for the prediction of speed of tennis serve. A total of 30 male junior AITA ranking players of three different tennis academy of Gwalior were selected by using purposive sampling. Videography method was used to biomechanically analyzes four phases of tennis serve i.e. moment stance position, moment preparatory phase, moment contact and moment follow through. For the purpose of the study, tennis serve speed was selected as dependent variable; and for independent variables; in linear kinematic variables i.e. Height of the Centre of Gravity at four phases of tennis serve and Angular kinematic variables i.e. Angle at Right Ankle Joint, Angle at Right Knee Joint, Angle at Right Hip Joint, Angle at Right Shoulder Joint, Angle at Right Elbow Joint and Angle at Right Wrist Joint were selected for the present study. Kinovea software was used in order to obtain the values of selected linear and angular kinematic variables and Bushnell Speed Gun was used to measure the speed of the tennis serve. Stepwise multiple regression analysis was conducted based on correlations between variables and the tennis serve speed. Positive correlations were found between the tennis performance and angle at knee & shoulder in preparatory phase and angle at hip in follow through. R2 was 0.662; highlighted that the regression equation explained 66.2 % of total variability. It could be said that above mentioned variables may predict the performance of speed of tennis serve.

OBJECTIVES OF THE STUDY

The objective of the present study will be to determine the muscle activation and Kinematic variables based on biomechanical analysis for the prediction of tennis serve.

METHODOLOGY

In this chapter selection of subjects, selection of variables, criterion measures, reliability of data, filming protocol, analysis of the film, administration of test and collection of data and the statistical techniques employed for analysis of data are discussed.

SELECTION OF SUBJECTS

For the study 10 male, university level tennis player will be selected purposively from Lakshmibai National Institute of Physical Education. Therefore it is considered that subjects posses reasonable level of technique of topspin service in tennis.

SELECTION OF VARIABLES

Based on literary evidence, correspondence with the expert and scholar's own understanding and keeping feasibility criterion in mind, the selected variables were as follows.

Kinematics variables:-

Linear kinematics:-

- Height of the centre of gravity at Stance Position.
- Height of the centre of gravity at preparatory phase.
- Height of the centre of gravity at the time of moment contact.
- Height of the centre of gravity at follow through)

Angular kinematics:-

- Angle at right ankle joint.

- Angle at right knee joint.
- Angle at right hip joint.
- Angle at right shoulder Joint.
- Angle at right elbow joint.
- Angle at right wrist joint.

The study will be confined to the activity in the following muscle:

- Triceps brachii
- Flexor carpi radialis
- medialis Deltoid
- Vastus lateralis
- Vastus medialis
- gastrocnemius

CRITERION MEASURE

1. The criterion measures for the study tennis serve performance i.e. accuracy of tennis serve will be assessed through Hewitt Tennis Test. The validity of the test is 0.625 to 0.93 and reliability of the test is 0.94.(Kansal, 2008) (Hewitt, May 1966)
2. The speed of tennis serve will be assessed through Bushnell Speed Gun at measure in kilometres per hour.
3. The angles will be measured in nearest degree at selected joints at four phases of tennis serve (Moment Stance, Preparatory phase, moment contact and Follow through).
4. Centre of Gravity will be measured in nearest distance from the ground at four phases of Tennis serve (Moment Stance, Preparatory phase, Moment Contact and Follow through).
5. contraction duration in second.
6.Duration from activation time to ball release in second.
7.Average rectified EMG for contraction in micro volt.

Procedure for Collection of Data

The technique of the subjects, filming protocol and analysis obtained were described as under:

Equipment -Two poles measuring 7 feet x 2 inch x 2 inch, a rope 1/4" thick; 36 heavy duty new tennis balls; tennis racquets; marking tape and measuring tape for tennis court markings for the test.

Instruments

For analysing the muscles activities, passive surface EMG will be used. Each subject's skin will be prepared for EMG electrode placement by shaving, abrading the skin and then cleaning the area thoroughly with an alcohol swab.

Filming Protocol

the biomechanical analysis of Tennis Serve videography was employed. GO PRO HERO 5 with the frequency of 240 frames per second was placed on the sagittal plane.

Administration of Test and Collection of Data

Hewitt Tennis Test: - Hewitt's tennis achievement test evaluates three basic skills in tennis at the university level—service, forehand, and backhand drives. By use of the "test-retest" method reliabilities range from .75 to .94. Validity coefficients for each of the three skills in tennis when compared with individuals' rank order of play ability range from .52 to .93.

The data indicate that the Hewitt service placement tennis test predicts best at the varsity level, whereas the revised Dyer wall test has the highest validity coefficient for advanced players. Hewitt's speed of service test as measured by the distance the ball bounces is the best test for beginners.

Reliability

To obtain reliable measurements, the instruments which will be used for the purpose of study namely, camera, steel tape, EMG instruments will all standard instruments as available at the Research Laboratory of LNIPE, Gwalior and hence their reliability will be insured. All the measurements pertaining to the selected kinematics variables will be taken by the research scholar under the expert's guidance, so the data collected for the study will be considered to be reliable.

Statistical technique

With the help of Statistical Package for Social Science (SPSS) version 26, the statistical analysis was done. In order to find out the prediction of tennis serve performance on the basis of muscle activation and kinematic variables stepwise multiple regression

analysis will be used. For testing the hypothesis, the level of significance was set at 0.05 .

EXPECTED OUTCOMES

The result of the this study may show -

1. It may show the significant prediction of tennis serve accuracy performance on the basis of selected kinematic and selected muscles variables.

2. It may the significant prediction of tennis serve speed performance on the basis of selected kinematic and selected muscles variables.

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